National Aeronautics and
Space Administration

Space Technology Mission Directorate
Game Changing Development Program

Affordable Vehicle Avionics Overview

14 July 2015

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Affordable Vehicle Avionics (AVA)

PROBLEM / NEED BEING ADDRESSED

SOA Avionics cost more than Nano-Launcher and low-cost payloads. Need affordable, responsive, modular common avionics system for Nano- Launchers

STATUS QUO

- Each NanoLauncher develops single use hardware and software .
- Avionics + Software costs are significant portion Launcher cost
- Avionics boxes today cost between $2M and $5M depending on functionality
- Software development cost over $1M per flight
- Current Business Model for Earth to orbit is fixed cost dominated.

NEW INSIGHTS

- The quality, consistency, and reliability in non-aerospace industries has improved such that their products may be used in traditionally aerospace applications.
- Fixed costs can be drastically reduced by utilizing non-aerospace COTS industry products & practices
- Building a common suite of Avionics and Software to be used by several launcher providers will lower costs

PROJECT DESCRIPTION/APPROACH

Technical Idea/Approach

- Partner with Nano-Launch Vehicle providers to develop a common modular avionics and software at a lower cost.
- Develop Avionics and Software emphasizing cost vs. performance, and exploit Model-Based Development.
- Exploit advanced sensor-fusion estimator software to compensate for low commercial-grade sensor accuracy.
- Employ an “Improve, Test, Fly, Improve” iterative design cycle approach.
- Identify broadly based, global industries that have achieved adequate levels of quality control and reliability in their products and then design around their expertise and business motivations.

QUANTITATIVE IMPACT

- Avionics costs reduced by 3 orders of magnitude, from $Millions to $Tens-of-thousands
- Cost per pound of payload for small satellites in the same range of large payloads (less than $10,000/pound)
- Fixed cost reduced by an order of magnitude

PROJECT GOAL

- Enable many launch vehicles capable of lifting 25kg to 750km circular orbit.
- Target recurring production cost of <$200K.
- Show potential for reduction of fixed cost by reduced personnel needs and minimal inventory requirements.

AVA Overview

Public and private "nanolaunch" developers are reducing the cost of propulsion, but conventional high-performance, high-reliability avionics remain the disproportionately high cost driver for launch. AVA technology performs as well or better than conventional GNCs, but with a fraction of the recurring costs. AVA enables nanolaunch providers to offer affordable rides to LEO as *primary payloads* – meaning, nano-sat payloads can afford to specify their own launch and orbit parameters.

Integration with other projects, programs, and partnerships:

- ADEPT project have purchased AVA for navigation and attitude determination on FOP SL11
- NRSAA with UP Aerospace for closed-loop control
- MSFC nanolauncher evaluating AVA on planned flight
- MSFC providing 0.5 FTE GNC competency

Technology Infusion Plan:

- Potential Partner (NRSAA in prog): AVA avionics; Piggyback/Close Loop flight tests - UP Aerospace, FY15/16/17
- PC: STMD/MSFC – MSFC NanoLaunch Technology Demonstration launches
- PC/Partner: GCD ADEPT Project
- PC: HEOMD/STMD/FOP; inexpensive launch to LEO; CubeSat Launch Initiative, etc.

Key Personnel:

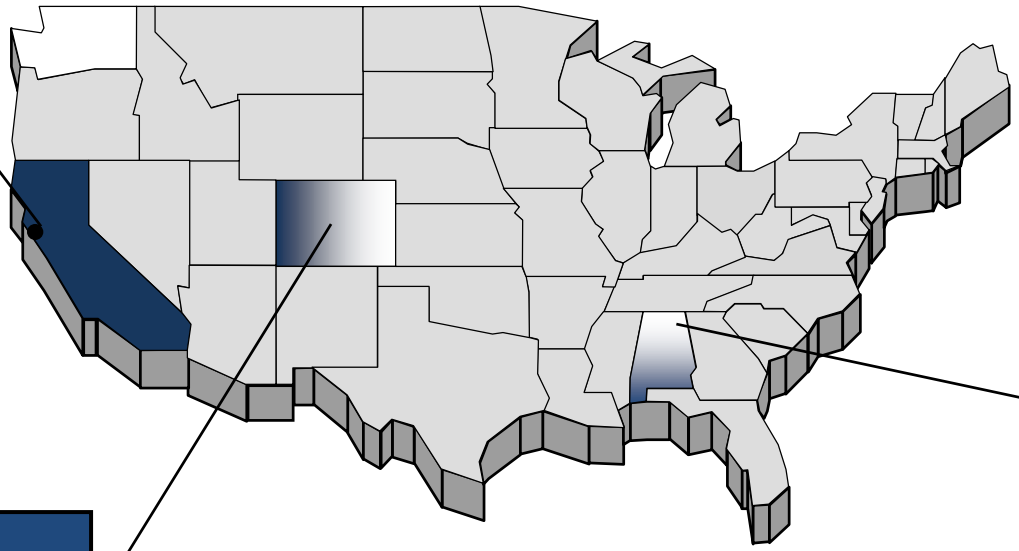
Program Element Manager: Wade May
Project Manager: Jim Cockrell
Lead Center: ARC
Supporting Centers: MSFC
NASA NPR: NPR 7120.8
Guided or Competed: Guided
Type of Technology: Push

Key Facts:

GCD Theme: Future Propulsion and Energy Systems
Execution Status: Year 1 of 2
Technology Start Date: Oct 1, 2014
Technology End Date: Sep 30, 2016
Technology TRL Start: TRL 5/6
Technology TRL End: TRL 7 Sub-orbital passive tests
Technology Current TRL: TRL 5/6
Technology Lifecycle Phase: Implementation (Phase D)

AVA Organizati

NASA ARC
AVA Project



NASA MSFC
Nanolauncher and
GNC consulting

UP Aerospace
NRSAA tests
leading to
controlled flight

AVA Resources

Key Milestones:

Milestone	Baseline Date	Current Date	Comment
AVA-1 FRR for UP Aero Flt via FOP	3/1/15	4/28/15	FOP UP Aero flight now 8/5/15
UP Aero Flight via FOP	3/15/15	8/5/15	FOP UP Aero flight now 8/5/15
AVA-1 FOP UP Aero Flight Results Report	8/1/15	9/10/15	FY15 **Controlled** Milestone, on track (CR in approval)
Continuation Review	9/15/15	9/15/15	

Quarterly Technical Accomplishments:

- Delivered AVA prototype to MSFC nanolauncher NL2A (cancelled)
- Overhauled 6DOF rocket model to become generic framework for all future LV-specific models
- Developed practical in-rocket magnetometer calibration/alignment procedure

Concerns:

- Cancellation of MSFC NL2A launch costs risk buy-down opportunity for higher-stakes FOP SL10 UP Aerospace SLXL launch
- Still working one high risk: GPS degradation of performance during rocket ascent

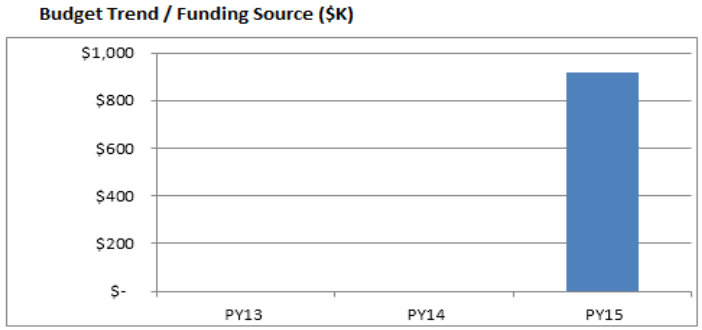
Cost	Schedule	Technical	Programmatic

Resources:

- FY2015: FTE: 4 WYE: .6
- FY2016: FTE: 4 WYE: .6

Budget ($K)	Q1	Q2	Q3	Q4	Total
Budget Allocation	$ 919	$ -	$ -	$ -	$ 919
Program Authority/ Funds Distribution	$ -	$ -	$ -	$ -	$ -
Obligated	$ 219	$ 379	$ -	$ -	$ 598
Costed	$ 219	$ 350	$ -	$ -	$ 569

Annual Budget Profile ($.919M)



			TTL Budget	
GCD Allocated	$ -	$ -	$ -	$ -
GCD Planned			$ 919	$ 919
Other Sources	$ -	$ -	$ -	$ -
Total Funding	$ -	$ -	$ 919	$ 919